

THUNDERSTORM AT TULSA, OKLA., JUNE 6, 1919.

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During the afternoon of June 6, 1919, the genesis and growth of a cumulus cloud through cumulo-nimbus into an unusually destructive thunderstorm were watched by the men on this station. As this storm started and attained its greatest fury within a few miles of this station it will be interesting to note the free-air conditions recorded shortly before the storm, especially since free-air conditions cannot usually be obtained by kites for several hours previous to such a storm on account of low wind velocities.

During the morning the wind was too light to sustain a kite, and the temperature rose from 14.5° C. in the morning to 31° C. in the afternoon. At 1:50 p. m. a south breeze became strong enough to start a kite flight, and at 3:33 p. m. an altitude of 2,691 meters above sea-level was reached.

A summary of the free-air data, computed by the Aerological Division, is given in Table 1. A notable feature of this table is the steep temperature gradient up to 1,500 meters. This condition was favorable to strong local convection; in this case, however, the gradients were scarcely sufficient to carry the rising air aloft to a point where condensation would occur. This saturation level would have been reached by convection ascent at an altitude of approximately 1,750 meters above sea-level, under the surface conditions recorded at 3:33 p. m., with a temperature of 30.4° C. and a dewpoint of 18.8° C. [$H_m = (t_a - t_{d.p.}) / .0077$]. In the region where the cumulus clouds started these superadiabatic gradients must have extended upward sufficiently high for condensation to begin in the rising air. Then, once condensation had begun the gradients noted in Table 1 would have been sufficient for the continued upward movement of the saturated air, and the growth of the large cumulus clouds observed.

The wind, as determined by pilot-balloon ascensions at 3 p. m. on the 6th and at 7 a. m. on the 7th, is shown in Table 3.

TABLE 1.—Free-air data from kite flight at Broken Arrow Aerological Station, June 6, 1919.

Time.	Surface temperature.	Relative humidity.	At different heights above sea.						Humidity.		Wind.	
			Altitude.	Pressure.	Temperature.	Δt 100 m.			Relative.	Vap. pres.	Direction.	Velocity.
P. M.	° C.	Per cent.	m.	mb.	° C.				Per cent.	mb.		m.p.s.
1:50	30.5	52	233	987.1	30.5				52	22.71	s.	5.4
			250		30.3				53	22.89	s.	5.4
			500		28.7				62	21.73	s.	5.8
			750		23.1				71	20.07	s.	6.2
2:25	30.4	52	845	920.4	21.8	1.42			75	19.59	s.	6.4
			1,000		20.2				76	18.00	s.	7.4
			1,250		17.7				79	16.00	ssw.	9.0
			1,500		15.2				81	13.99	ssw.	10.6
2:52	30.4	52	1,531	849.3	14.9	1.01			81	13.72	ssw.	10.8
			2,000		11.8				67	9.27	sw.	16.1
3:06	30.8	51	2,216	782.7	10.4	0.66			60	7.57	sw.	18.6
			2,500		8.8				46	5.21	wsww.	19.7
3:33	30.4	50	2,691	738.6	7.8	0.54			37	3.91	wsww.	20.4
			2,500		8.8				49	5.55	wsww.	19.6
			2,000		11.4				80	10.78	sw.	17.6
3:57	30.3	51	1,979	804.6	11.5	0.92			81	10.99	sw.	17.5
			1,500		15.9				80	14.46	ssw.	13.2
4:21	31.0	50	1,282	873.4	17.9	1.01			79	16.20	ssw.	11.2
			1,250		18.2				78	16.30	ssw.	11.2
			1,000		20.7				70	17.09	ssw.	11.5
			750		23.3				63	18.02	s.	11.7
4:46	30.4	52	540	950.8	25.4	1.50			56	18.17	s.	11.9
			500		26.0				55	18.49	s.	11.6
			250		29.7				51	21.28	s.	9.5
4:52	30.0	51	233	984.2	30.0				51	21.64	s.	9.4

TABLE 2.—Clouds observed during kite flight.

Time.	Amount.	Kind.	Direction.
	<i>Tenths.</i>		
1:50 p. m.	1	St. Cu.	sw.
2:21 p. m.	2	Cl. Cu.	w.
	1	St. Cu.	sw.
2:57 p. m.	1	Cl. Cu.	w.
	1	A. Cu.	w.
	1	St. Cu.	sw.
3:28 p. m.	1	A. Cu.	w.
	Few.	Cu.	w.
	1	St. Cu.	sw.
4:15 p. m.	Few.	Cu.	w.
	1	St. Cu.	sw.
4:46 p. m.	2	Cu. Nb.	w.
	Few.	St. Cu.	sw.

TABLE 3.—Wind direction and velocity, by pilot balloons.

Altitude above station (meters).	June 6, 3 p. m.		June 7, 7 a. m.	
	Direction.	Velocity.	Direction.	Velocity.
Surface.....	S	m. p. s. 5	ENE	m. p. s. 3
500.....	SSW	5	SSW	9
1,000.....	SW	10	SSW	13
2,000.....	WSW	15	SW	13
3,000.....	W	18		

NOTE.—Station elevation, 233 meters.

At 3:28 p. m. the summits of a few cumulus clouds began to appear. One anvil shaped cumulus was seen to the northeast, and a row of three or four mountainous peaks stretched away to the west. At 4 p. m. an immense cumulus cloud estimated to be 40 or 50 kilometers away to the west-northwest, with a summit extending through the alto-cumulus layer and to a considerable distance above it, began to show signs of precipitation, and at 4:42 p. m. the first thunder was heard. At this time there was a well-marked area of precipitation in the center of the cloud and the whole mass was moving slowly eastward.

As the storm approached it increased rapidly in size and a veil of false cirrus overflowed eastward and southward. Underneath the anvil portion which extended forward the cloud took a well-developed mammato-cumulus form. A continuous roar of thunder in the upper portion of the cloud was heard for perhaps half an hour before the arrival of the storm.

The storm moved from the west, i. e., with the wind at 2,500 meters altitude and higher, and covered Tulsa County and adjoining territory. The destructive violence was spread over several square miles, and extended from Collinsville on the north to Bixby on the south (see map). One child was killed at Bixby, several people were injured in various places by falling buildings, and damage to property and farm crops amounting to more than a million dollars was sustained. The damage resulted from a combination of wind, hail, and rain.

The anemometer at Broken Arrow recorded an extreme wind velocity from the north-northwest of 80 miles per hour (36 m. p. s.) and a maximum velocity for five minutes of 67 miles per hour (30 m. p. s.) at 6:28 p. m. Five or six miles farther west the wind appeared to have been more violent. A schoolhouse (fig. 1) and a large barn, just completed, were blown down, and several farmhouses and barns were unroofed. At

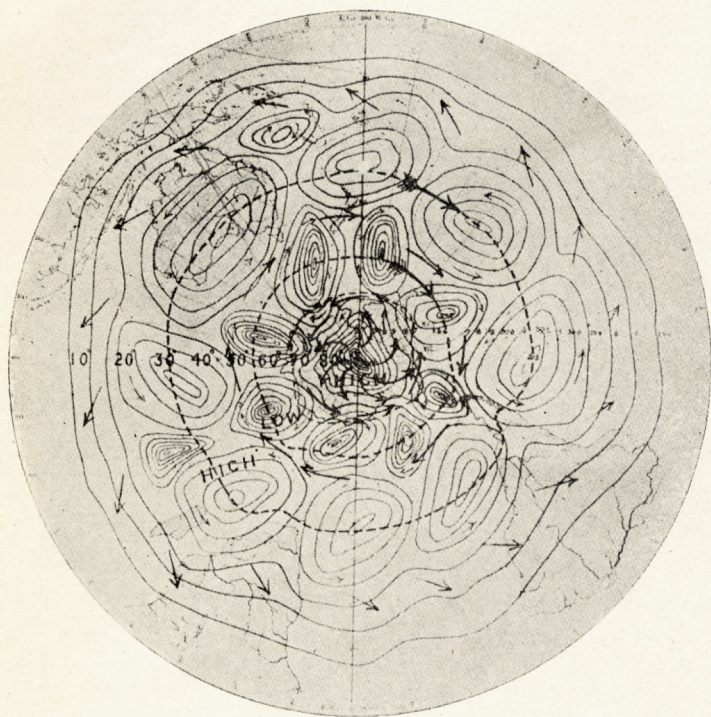


FIG. 1 (H. H. H.)—Southern Hemisphere circulation. (Lockyer.) (See p. 375.)

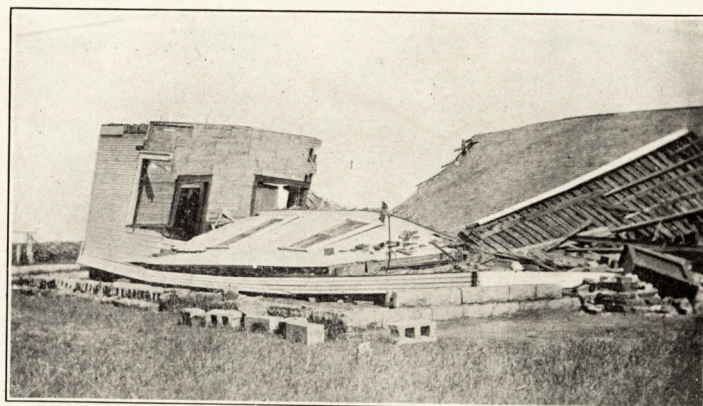


FIG. 1.—Union Schoolhouse, 5 miles west of Broken Arrow, blown down by the wind. Taken from the northwest. School library before the first window laid out to dry.

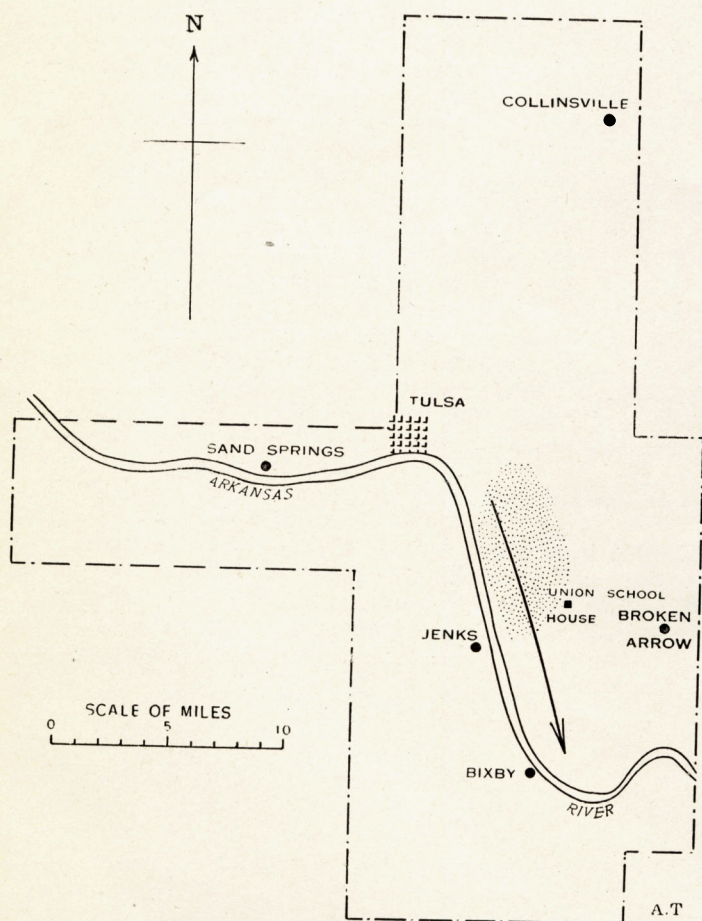


FIG. 2.—Map of Tulsa County, Okla., showing region of cloudburst of June 6, 1919. Arrow indicates region of destructive winds. Dotted area shows region of most violent hailstorm.



FIG. 3.—Home of E. L. Levin, 1602 South Boston Street. The flood swept this 6-room bungalow several yards from the foundation. The house was completely filled with water.

Bixby 20 houses were reported to have been demolished, and a number of oil tanks were damaged or blown away. This wind was not of tornadic character, but simply a straight blow with a front of 8 to 10 miles or more.

The heaviest rainfall, amounting in popular language to a cloudburst, fell in Tulsa, where 5.80 inches was recorded. At Broken Arrow 1.05 inches was recorded. These amounts are somewhat deficient on account of the high wind that accompanied the heaviest downpour. Hailstones 1 inch in diameter fell in Broken Arrow; in Tulsa one hailstone was found to measure 8 by 6½ inches in circumference, and another weighed 44 ounces. The heaviest fall of hail occurred between Broken Arrow and Tulsa, shown by the dotted area on the map (fig. 2).

TORNADO AT FERGUS FALLS, MINN., JUNE 22, 1919.

On the afternoon of Sunday, June 22, 1919, at 4:45 p. m., the town of Fergus Falls was struck by a tornado which, almost in a twinkling, razed 228 houses, killed 57 people, and injured many more.

From descriptions given by persons who saw the tornado as it approached the city it appears that it was accompanied by all the phenomena which characterize such storms—a black, funnel-shaped, “twisting” cloud, or several of them, a heavy downpour of rain, and a terrific roar. Mrs. Elsie Rathbun, who watched the storm from the Great Northern Railway Station, is quoted in the Minneapolis Tribune as saying that “the storm approached rapidly, with black clouds pushing up from the west toward the city. Just before it struck Fergus Falls there was a humming like a dozen factories all full of buzzsaws running at once, and then when the storm arrived there was a pandemonium of noise.” Richard Krynen, according to the same paper, also watched the storm from the Great Northern station. He is quoted:

For a considerable time before the tornado struck there was a rumbling sound, and then it started to rain and rained hard. We thought the rain was going to stop, but hailstones the size of marbles began to fall.¹

Quoting from the Minneapolis Journal of June 23, 1919:

The first storm, they say, struck the town from the northwest, and tore through the Lake Alice district. This was the one that wrecked the Grand Hotel. The second storm, which brought driving rain, approached from the southwest. A third, it is claimed, swept over the eastern portion of the town from the southeast, but did less damage.

Fergus Falls, with a population of 12,000, is situated in northwestern Minnesota. The town is divided into two sections, north and south of the Red River. It was the north portion that was demolished. See figures 1 and 2.

Telegraphing over hay-bale wire from Fergus Falls two days after the tornado occurred, Carlton W. Miles, of the Minneapolis Journal, said:

“Half the town looks like a vast acreage of kindling; the other half, save for trees split at the roots, is unharmed.”

But while it is true that only half the town was demolished, the line of wreckage could be clearly traced for a distance of 10 miles to the east, and a bank check was picked up 60 miles away. The property loss was \$3,500,000, of which \$500,000 was in automobiles, many of which were caught by flying débris. In one instance the force of the wind split a huge tree, threw

Here the hailstones said to have been the size of hens' eggs fell in large quantity. Over a wide area in this section the hail caused almost a total loss of what had promised to be an abundant crop of wheat and oats. Corn was torn to shreds, gardens obliterated, and fruit, particularly peaches, of which there were a number of commercial orchards, was nearly all knocked from the trees, while even the bark was seriously injured by the hail.

The flood in Tulsa resulting from the excessive rain caused property damage amounting to thousands of dollars. Houses were moved from their foundations (fig. 3), and garages and automobiles were washed away by a torrent several feet deep that raged through the lower sections of the city.

an automobile into the intersection, and then closed up the opening, holding the machine like a vise.

The following are some of the remarkable freaks of the tornado as recorded in the Minneapolis Journal of June 23, 24, and 25, 1919:

Wind force.—A trunk with clothing was carried from the residence of E. T. Barnard into the attic of a house two blocks away. The trunk was found uninjured.

A slender weed was driven 6 inches into a heavy plank.

Clover leaves were driven into the plaster in many residences on the north side of the river.

The Great Northern “Oriental Limited,” west-bound, was traveling between 30 and 40 miles an hour when the twister struck the baggage car behind the tender when about 6 miles east of Fergus Falls, throwing 7 of the 11 coaches from the rails. The baggage car was torn out of the train and set down about 30 feet from the rails at right angles to them. The suction also tore out the track under this car.

Suction (explosive expansion of air as low pressure of tornado passed).—In homes where there were stained-glass windows, the colored portion is intact although the regular window glass is broken.

In many homes all the clothing stored in closets disappeared in the storm.

In one flock of 30 chickens all their feathers were stripped off, and the chickens were found in the hen-house sitting up stiffly at attention. All of them were dead.

Agnes Palm, the little daughter of August Palm, was sitting on her father's lap in their home on the east side of Lake Alice. The father, mother, and sister were killed, but little Agnes escaped injury, although her shoes were torn from her and she was set down a short distance away.

Localization of damage.—Three houses stand alone on Cleveland Avenue north. The top story of each is sliced off as clean as if with a cleaving knife.

In the Knoff residence a cut-glass vase was carried from its resting place on a buffet over a pile of dishes, around a corner into the living room and was found unbroken on the floor.

The Levorsen house on Lakeside drive was so badly damaged that it was deemed unsafe to enter it. * * * All the furniture was in splinters except the buffet, which was moved 2 feet from the wall with not a dish broken.

In one house every stick of furniture was destroyed with the exception of the piano and a talking machine, which were not even scratched.—H. Lyman.

¹ The *Literary Digest*, New York, July 26, 1919, pp. 38 and 40, has a detailed account of this storm and the damage wrought.